Limnologica 29 (1999) 282–285
http://www.urbanfischer.de/journals/limno

LIMNOLOGICA

Geological Survey of Estonia, Tallinn, Estonia

Development of Drinking Water Resources in Coastal Areas of Estonia

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With 2 Figures

Key words: Estonia, coast, drinking water, sea water

Abstract

For a sustainable development of Estonia's coastal region it is necessary to achieve a balanced proportion between purified surface water and deep groundwater for public drinking water supplies. Special attention should be directed to problems of sea water encroachment into coastal aquifer systems. Only close co-operation between surface water specialists, hydrogeologists, and socio-economists will be able to solve this sophisticated task.

Most of the population and industrial enterprises are concentrated in the coastal region of Estonia (Fig. 1). Here is located the capital, Tallinn, with about a half million of inhabitants. The world's largest commercially exploited oil shale deposit with numerous mines, processing plants and power stations is in the coastal area of North-East Estonia. The popular seaside resorts and important regional economic centres Pärnu, Haapsalu and Kuressaare are in West Estonia.

Huge industrial, agricultural, military, and municipal pollution sources came into Estonia during the period of socialist economy from 1946 until 1991. Industrial pollution of the hydrosphere was connected chiefly with mining and processing of oil shale. Many toxic substances such as polycyclic aromatic hydrocarbons including carcinogenic compounds, hydrogen sulfide, sulphuric acid, formaldehyde, benzene, toluene, and the finest fraction of oil shale ash were discharged into the atmosphere by power stations and chemical plants (LIBLIK & RÄTSEP 1994). The concentration of harmful substances in the atmosphere exceeded German standards by a factor of 5 or more in some places. Major point-sources of pollution were the ash plateaus of power stations and oil shale mines (VALLNER & SEPP 1993). About 800 tonnes of phenols annually were carried into the River Purtse, making it one of the most polluted rivers in Europe.

In the countryside, manure from the large livestock farms that were built was washed out with water to form slurry (VALLNER 1994). Instead of mature farm manure, large amounts of mineral fertilizers were used. As a result about 30% of all checked wells still showed nitrogen contents higher than permitted limits even recently (Põllumajanduslik ... 1994; TENNOKESSE 1991).

Oil pollution caused by leakage of oil tanks and pipelines occurred in many places, and especially in military bases, most of them were located in coastal areas. At one former military airfield near Tapa, so much jet fuel seeped into the ground that some of it emerges through springs on the slopes and flows into streams (SALU & NIELSEN 1992). The landfill of a former nuclear plant containing As, Bi, Cu, Hg, Pb, and U on the shore at Sillamäe is a potential pollution source endangering the entire Gulf of Finland (PETERSELL et al. 1994).

The joint effects of all these pollution sources aggravate the difficulties in maintaining safe public drinking water supplies in coastal regions of Estonia. As in the areas with severe nitrogen and oil pollution, most shallow groundwater in the north-east mined regions is unsuitable for drinking. Owing to its poor quality, the purification of surface water to meet all requirements is very expensive.

However, there exists a deeper, so called Cambrian-Vendian (Є-V) aquifer system in North Estonia that stretches along the sea shore and contains great amounts of fresh water with values of $\delta^{18}O$ from –1.8 to –2.2% (VALLNER 1994). Consequently, this water must originate from the thawing of the glacier sheet at the end of the Pleistocene. This Pleistocene fresh water being totally uncontaminated by contemporary pollution, should be considered as one of the most valuable natural resources of Estonia.

The Є-V aquifer system, having a southward inclination, outcrops at the bottom of the Gulf of Finland (Fig. 1). The good drinking water of deep strata is already widely used in the North Estonian coastal region, but due to intensive

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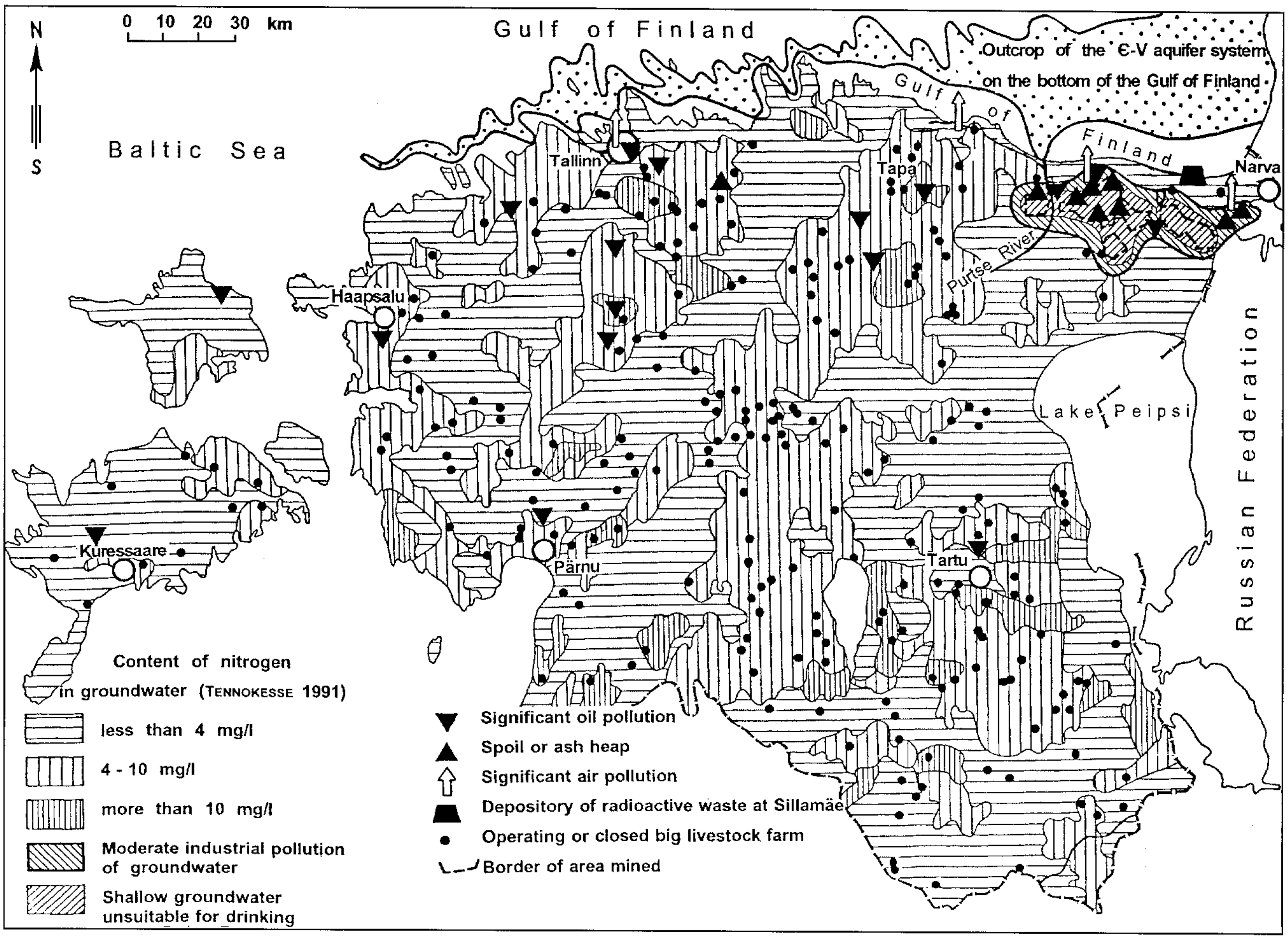

Fig. 1. Quality and pollution sources of groundwater in Estonia.

pumping the potentiometric surface of aquifers was lowered by up to 60 m below sea level. Originally, it was about 5 m above sea level at the shore. Thus, salty sea water may intrude into numerous wells tapping the Є-V strata in coastal area.

This very complicated situation gives rise to the main water management problems in Estonian coastal areas: in which optimal proportions should purified surface water and deep good-quality groundwater be used for public drinking water supplies?

Some apprehension has been expressed about the intensive extraction of deep groundwater. It is thought that this clean groundwater, the most valuable natural resource of Estonia, should be preserved so far as possible for the coming generations. Some specialists believe that the safest way to maintain the public drinking water supplies would be to link the channel networks, to gather the streamwater in open reservoirs and to purify it by means of contemporary high-technology methods. The channel networks would have to be interlinked because the run-off of Estonian rivers is smallish and seasonally irregular.

Significant progress has already been made in this direction. For example, about 70% of the whole drinking water supply of Tallinn is based on surface water taken from a lake that is artificially recharged by several rivers of North Estonia. However, it should be noted that plankton abundances in the lake are high, owing to the high nutrient concentration in the stream water. Therefore, excessive amounts of chlorine and coagulants were used to purify raw water, causing clogging in the pipelines. To improve the quality of the processed water, very expensive treatment of all raw water with ozone is carried out.

Others, however, emphasize that from the viewpoint of the health care it is much better to drink pure groundwater than treated surface water. They contend that nobody knows exactly how people are affected by the polycyclic aromatic hydrocarbons, heavy and trace metals, and other wastes of contemporary society that enter municipal waterworks in microquantities in spite of all treatment where surface water is used. Thus, drinking of purified surface water should be avoided as far as possible if unpolluted natural groundwater is available. The existing human generation should not be protected less than the coming ones.

Sea water intrusion could be prevented by using a different basin pumping pattern. If pumping were concentrated as far as possible from the seashore, deeper drawdown will increase the recharge of the aquifers from overlying inland strata, whereas reduced pumping near the coast might raise the groundwater level and thus prevent the intrusion of sea water.

It is advisable to recharge deep aquifers artificially. In many places in North Estonia the water table of the upper aquifers is 20–80 m higher than the potentiometic surface of underlying deep aquifers. Upper and deep aquifers could be linked by recharge wells. The shallow groundwater would then intrude into the deep aquifers without pumping, thereby increasing their reserves.

The high-quality ancient water extracted should be regarded as a valuable non-renewable mineral like petroleum or coal, the use of which is dictated by economic and social considerations. If necessary, pumping from deep aquifers may continue at present levels or even significantly increase, but society must be aware that the deep groundwater gained will ultimately be replaced by sea water or deep connate brines.

A typical example of this situation can be seen in industrial North-East Estonia. The Kurtna Landscape Reserve in the centre of the region includes 40 picturesque lakes amidst sandy hillocks and ridges (Fig. 2). A fluvioglacial aquifer under the landscape reserve was relatively unpolluted, so a groundwater intake was put into operation to supply additional water to the Kothla-Järve urban area. Unfortunately, the intensive pumping has lowered the water table of many lakes to below their acceptable minimum level, and the unique hydrobiological lake associations and the amenity value of the landscape has suffered significantly (MÄEMETS 1987). To improve the ecological situation it is planned to shut down the groundwater intake, but in this case a new source of good drinking water supplying at least 10 000 $m^3 \times d^{-1}$ will have to be found for the Kohtla-Järve area.

Total pumping from the Ꞓ-V strata for the Kohtla-Järve urban area was approximately 30 000 $m^3 \times d^{-1}$ at the drawdown, reaching 45 m in the centre of the depression cone in 1995. As a preliminary result of hydrogeological modelling carried out by Geological Survey of Estonia it was evident that increasing the pumping rate by 10 000 $m^3 \times d^{-1}$ will cause an additional drawdown of up to 20 m, but the potentiometric surface of the aquifer system will remain above the bottom of the upper confining aquitard. The supplementary wells should be placed at a distance of 10 km SW of the existing drawdown epicentrum.

As groundwater extraction increases, the advances of saline sea water along the aquifer towards the Kohtla-Järve area will accelerate. At present intensity of deep groundwater pumping rate, the sea water intrusion should not reach the coastal wells tapping the Ꞓ-V aquifer system on the shore of North-East Estonia before 2030. This would happen 10 yeas earlier if the pumping rate were increased by 25%.

In Tallinn, where resources of good natural drinking water are restricted, it is highly advisable to install a second distribution system delivering only clean groundwater (VALLNER

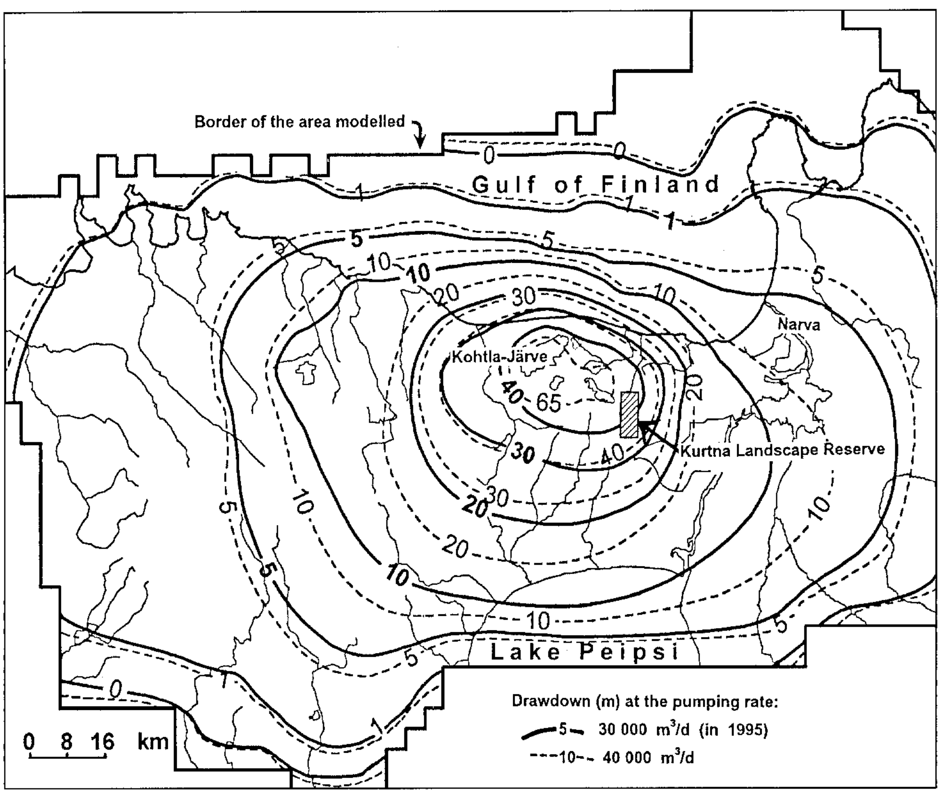

Fig. 2. Potentiometric surface of the Cambrian-Vendian aquifer system simulated for North-East Estonia.

1995). This will be quite expensive, but the whole project may be implemented gradually as funding becomes available.

In view of this complex situation in which everything is mutually dependent, a well-founded long-term integrated water management plan is urgently needed for coastal regions of Estonia. This will involve considering surface water, groundwater, hygienic, social, and environmental problems together in both a local and a wider regional context. Integrated water management involving the intensive development of deep aquifers may be successfully carried out only on the basis of a thorough basin-wide modelling of groundwater flow and transport. The results of modelling and other investigations should be used for a convincing assessment of environmental, social, and economic risks relating to water resources management. Until this has not been done, an optimal public drinking water supply is impossible in coastal regions of Estonia.

The modelling of sustainable pumping conditions for deep aquifers was initiated at the Geological Survey of Estonia in 1995. The first stage is inteded to elucidate the possibilities for modifying the basin pumping pattern to achieve the most favourable usage of the groundwater in the heavily polluted coastal region of industrial North-East Estonia.

References

LIBLIK, V. & RÄTSEP, A. (1994): Pollution sources and distribution of pollutants. In: J.-M. PUNNING (ed.), The influence of natural and anthropogenic factors on the development of landscapes, pp. 70–93. Tallinn.

MÄEMETS, A. (1987): Kurtna järvede unikaalsusest, tüpoloogiast, muutumisest ja kaitsest [About the uniqueness, typology, altering, and protection of Kurtna Lakes]. In: M. ILOMETS (ed.), Kurtna järvestiku looduslik seisund ja selle areng [Natural state of Kurtna Lakes and its development], pp. 165–171. Tallinn.

PETERSELL, V., RESSAR, H., MÕTTUS, V., OLSSON, A., UNT, L. & VÕSU, M. (1994): Geochemical atlas of the humus horizon of soil and upper layer of peat deposits of Northeast Estonia. Tallinn – Uppsala.

Põllumajanduslik hajureostus lämmastikuühenditega Eestis. Typpi Keskin-Suomen vesissa. [Agricultural non-point nitrogen pollution in Estonia. Nitrogen in the waterbodies of Central Finland] (1994). AS Maves. Keski-Suomen vesi- ja ümpäristöpiiri. Jyvasküla.

SALU, M. & NIELSEN, J. (1992): Investigation of oil pollution at the Tapa military airfield. Copenhagen.

TENNOKESSE, V. (1991): Otcet o rabotah po ohrane podzemnyh vod za 1989–1991 gg. [Report about groundwater protection in 1989–1991]. Tallinn.

VALLNER, L. (1995): Problems of water supply in Estonia. In: J. NIEMCZYNOWICZ & K. KRAHNER (ed.), Integrated water management in urabn areas, pp. 281–292. Lund.

– (1994): Problems of groundwater quality management in Estonia. In: K. KOVAR & J. SOVERI (eds.), Groundwater quality management, pp. 449–460. Wallingford.

– & SEPP, K. (1993): Effects of pollution from oil shale mining in Estonia. Land degradation and rehabilitation **4** (4): 381–385.

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